

# Vapor Intrusion Mitigation Measures at the Former Bethlehem Steel Plant

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# Bethlehem Steel Plant, Bethlehem, Pa.

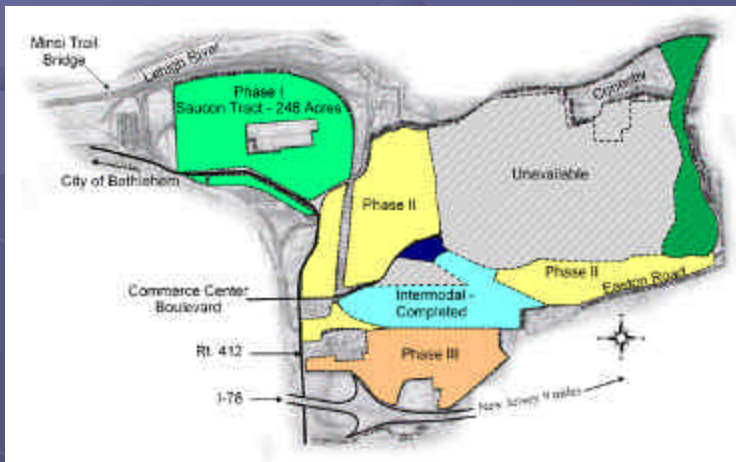


- The Site was owned and operated by Bethlehem Steel Corporation from the late 1800s through the late 1990s.

# Site History



- May 2004 – LVIP purchases ~1,100 acres of the Bethlehem Plant
- Redevelopment plans include
  - Manufacturing
  - High-tech operations
  - Warehousing
  - Distribution
  - Office space



# Slag Bank 3



- 47 Acres
- Up to 40 feet of fill
  - Slag
  - C&D debris
  - Coking Residuals
- Scrap metal sorting and storage
- Up to 40 feet of fill



# Crystal Lake



- Un-lined surface impoundments
- Operated from 1950s
- Closed by filling with blast furnace and BOF slag in 1978

# Systematic Site Characterization

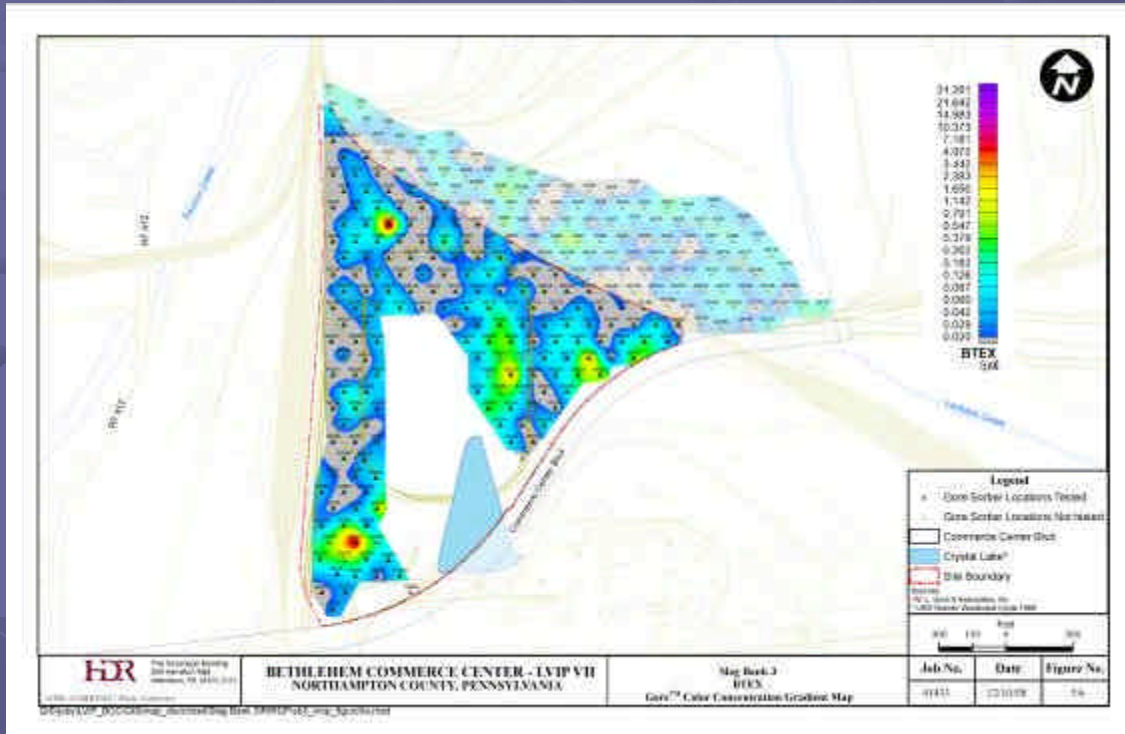


- Passive soil gas sampling utilizing Gore™ modules
- Targeted active soil gas sampling
- Test Trenching



# Passive Soil Gas Sampling

- 285 Gore™ Modules
- Measures soil gas mass in vapor phase
- Color Gradient Maps



# Active Soil Gas Sampling



- 21 Sampling Locations
- Nested wells at 5, 15, and 30 feet BGS
- 2 Rounds of soil gas
- Summa Samples
- TO-15 (w/ Naphthalene)



# Test Trenches



- 16 Test Trenches
- ~3,800 linear feet of trenches
- 93 Soil Samples
- Full TAL/TCL Analysis

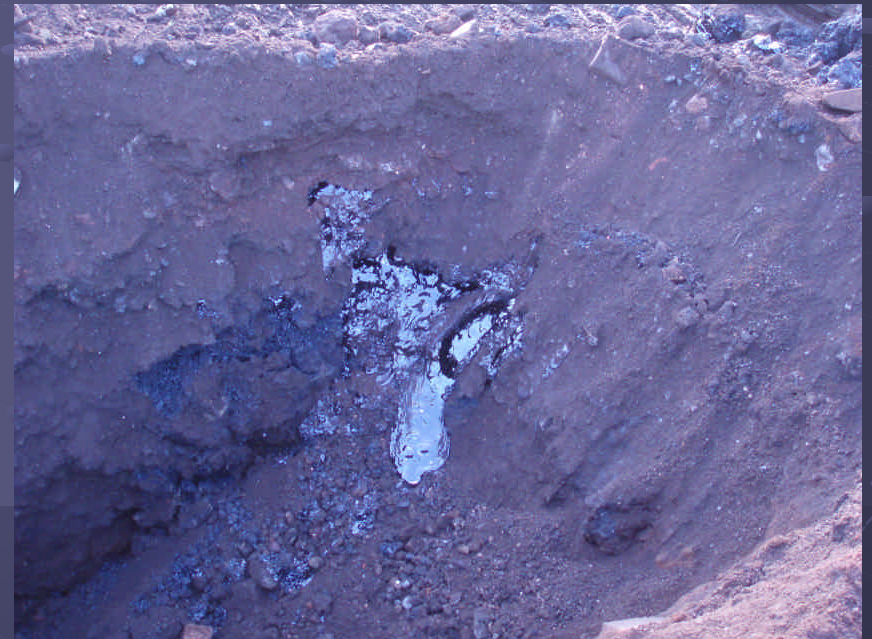


# Site Characterization Results

## Soils

### ● Compounds above the PADEP MSC<sub>Soil</sub>:

- BTEX
- PAHs
- Metals
  - Antimony, iron, lead, selenium, mercury



# Site Characterization Results

## Soil Gas



● Primary compounds above the PADEP  $MSC_{SG}$ :

- Benzene
  - 1,200 – 32,000,000  $\mu\text{g}/\text{m}^3$
- Naphthalene
  - 1,300 – 380,000  $\mu\text{g}/\text{m}^3$
- 1,2,4- and 1,3,5-TMB
  - 3,400 – 59,000  $\mu\text{g}/\text{m}^3$

# Soil Gas Risk Analysis

- J&E Model
- Combination of site specific and PADEP default input parameters
- Health risk exceeds the applicable HQ/IR in the southern portion of the Site



# Proposed Development



- 720,000 ft<sup>2</sup> warehousing / distribution center
- Paved driveways, parking, truck loading areas
- Rail spur
- Lined bioretention areas



# Cleanup Approach

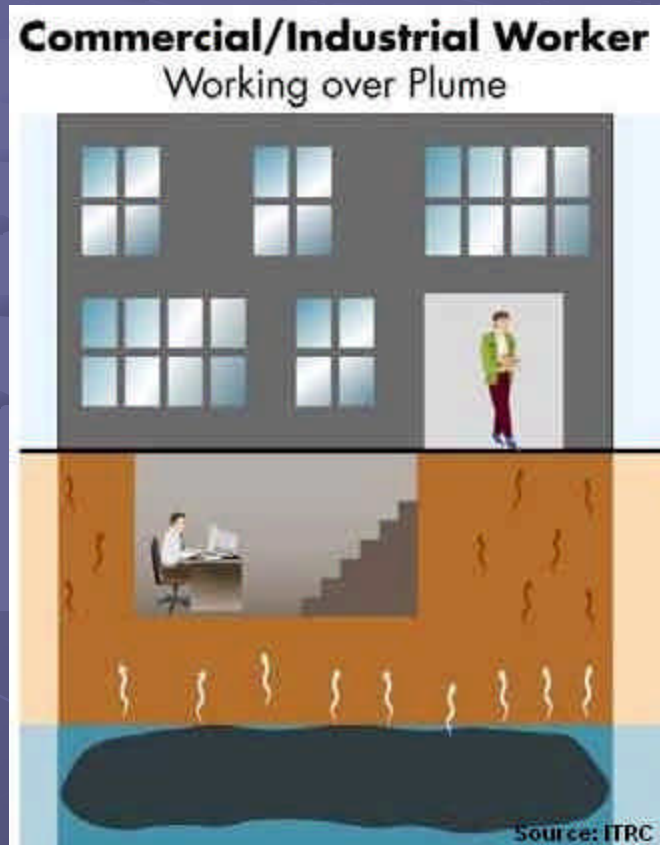
## Soil:

- Soil Management Plan / On-site Reuse
- Pathway Elimination
  - Capping
  - Deed Restriction





# Cleanup Approach

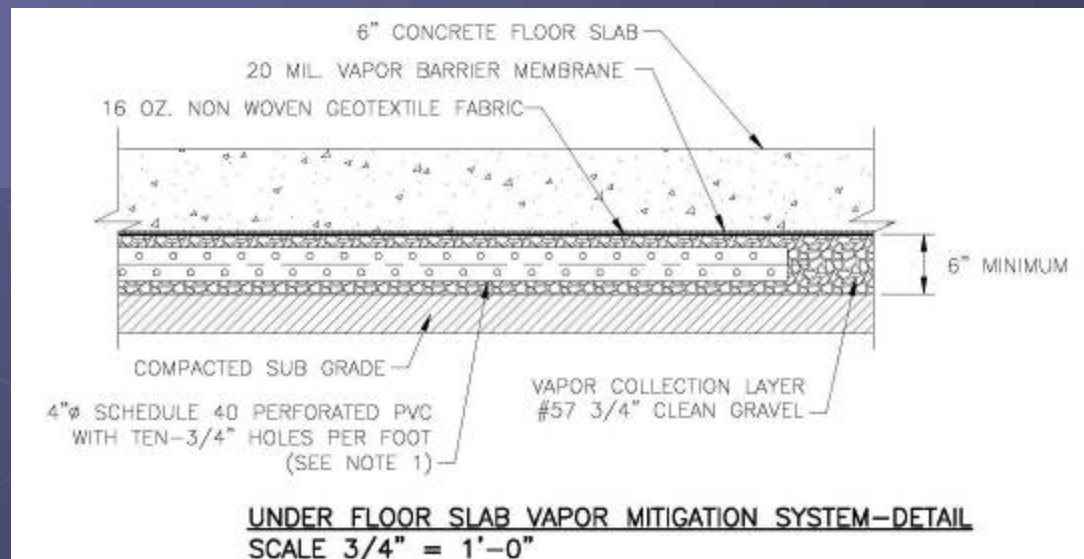


## Soil Gas:

- Vapor Mitigation System
- Capping to reduce infiltration
- Indicator barrier
- Deed Restriction

# Vapor Mitigation System Components

- Vapor barrier membrane
- Vapor collection layer
- Sub-slab depressurization



# Vapor Barrier Membrane

- Vapor Block Plus 20-mil (VBP-20)
  - 20 – 200 times more impermeable to VOCs than polyethylene
  - Exceeds ASTM 1745
- Geotextile Cushion



# Vapor Collection Layer

- 6" Clean course aggregate
  - ½" to 1" diameter
  - <10% passing ½-in sieve
  - 50% free void space
- 4" Diameter perforated PVC pipe
  - Ten ¾-inch holes per foot
- Horizontal vent pipe

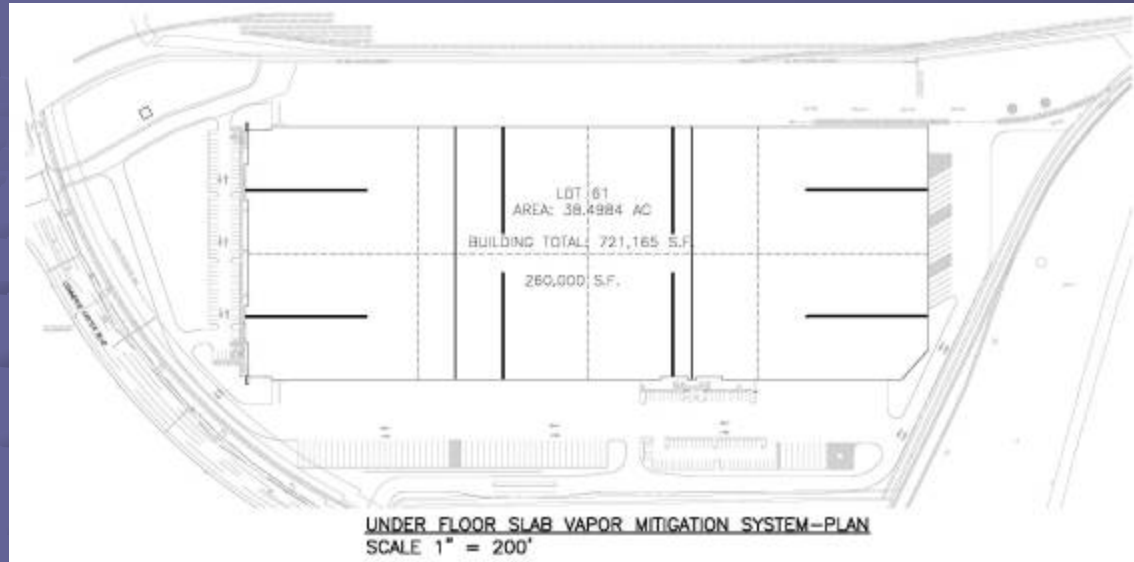
# Sub-Slab Depressurization

- Powered exhaust fans
  - Installed in-line with vertical pipe run
  - Draws air from vapor collection layer and vents above roofline





# Design Considerations



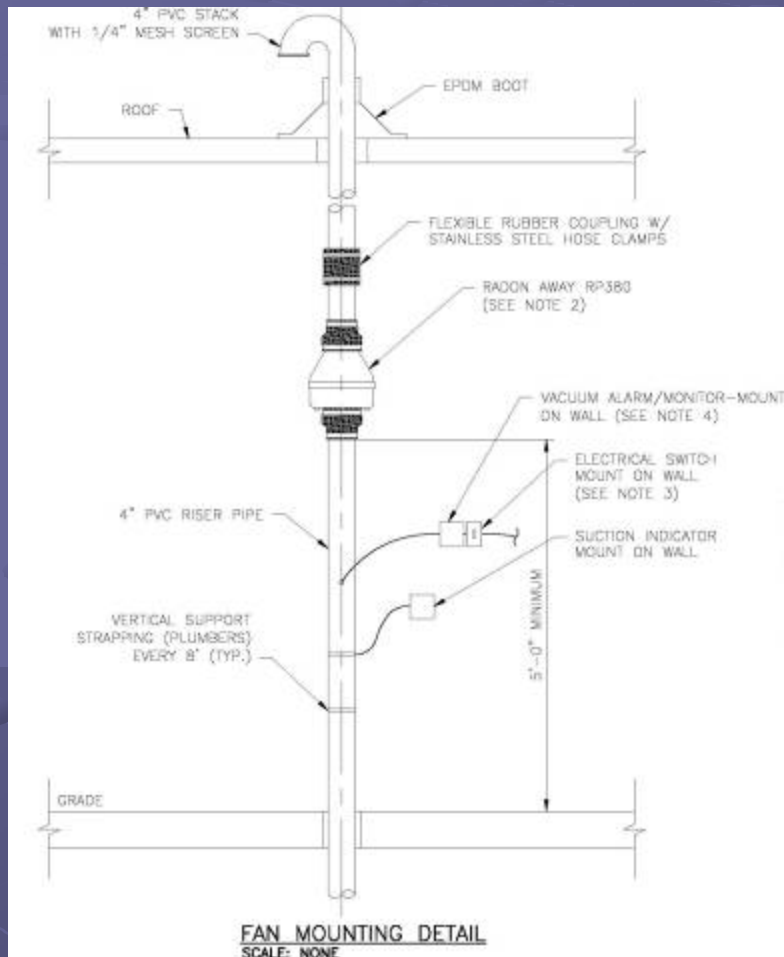
- Building size

- One 4-ft. x 4-ft. x 8-in. suction pit or 240 linear feet of perforated PVC pipe per 100,000 ft<sup>2</sup> of building.

- Fan Selection

- Low Pressure/High Flow vs. High Pressure/Low Flow
- For large buildings use in-line duct fans with a flowrate of 500-600 cfm @ 0" static pressure

# Design Considerations



## ● Fan Discharge

- Terminate at least 12 inches above roofline
- Terminate at least 10 feet from windows or openings
- Terminate at least 10 feet from adjacent buildings

# Design Considerations

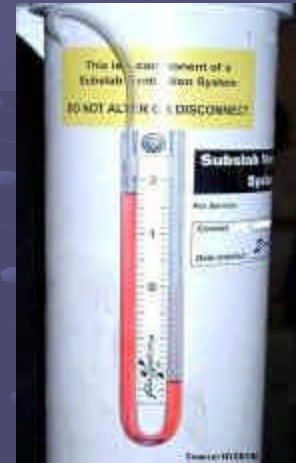


- Condensation and GW Interference
  - Pitch horizontal pipe runs
  - Install Condensate Bypass
  - Elevate Fan

# Design Considerations

## ● Gauges and Alarms

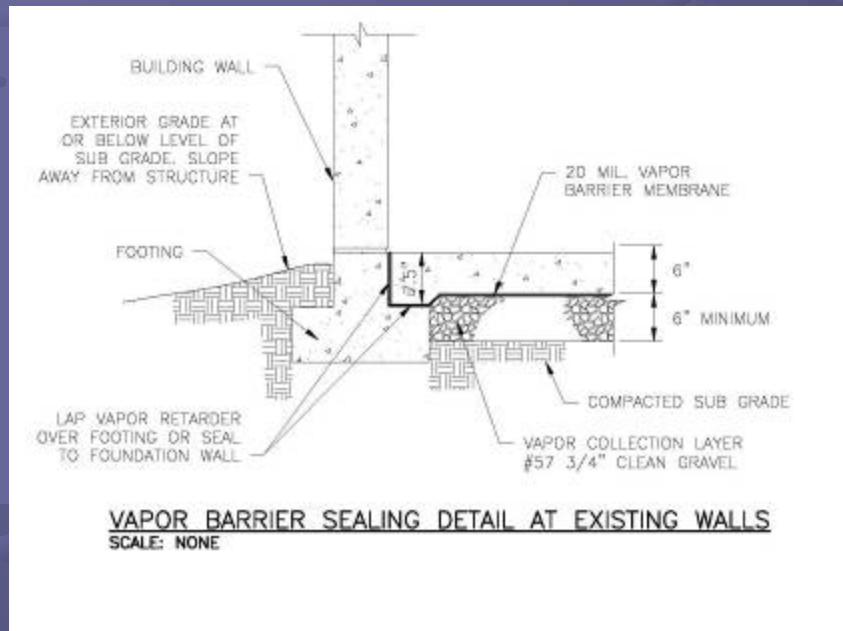
- Manometer
- Magnehelic
- Audible/Visual Alarm



# Design Considerations

## • Joints, seams, and penetrations

- Seal at wall joints
- Overlap and tape seams
- Cuff and/or tape penetrations





# Confirmation Sampling



- Confirm sub-slab negative pressure field

OR

- IAQ Monitoring
  - Perform at least 2 weeks after system startup
  - Possible background interference

# Operation and Maintenance

## ● Monthly Inspection

- Pressure gauges
- Vent pipes
- Alarm

## ● Annual Inspection

- Fan bearings
- Discharge locations
- HVAC system
- Floor slab

# Does it really cost that much?

- Sub-slab aggregate drainage beds are installed in most areas of the U.S.
- Building code typically requires moisture barrier
- Radon pumps cost about the same as a light bulb to operate
- Incremental installation cost can be as little as \$1.00/sf

# References

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- New Jersey Department of Environmental Protection. Vapor Intrusion Guidance. October 2005.
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- United States Environmental Protection Agency. Radon Prevention in the Design and Construction of Schools and Other Large Buildings. June 1994.